# Space Weather Technical Forecast

Issued on Friday, 10 November 2023 at 13:27 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Chance of a G3/Strong geomagnetic storm late 11 or early 12 Nov. Active fluence (1e8 integrated pfu) ongoing. Chance of isolated M-class flares.**

## Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Activity has been Low with only C-class flares observed in the last 24 hours, the largest a C2 at 09/1118 UTC in the vicinity of AR3480. There are currently seven regions on the visible disc. AR3483, in the southwest, is the most complex spot on the disk, now with a delta magnetic structure in it's trailing portion, and maturing penumbra within the intermediate spots. AR3477, in the southwest remains the largest group, comprising of one large, asymmetric and mature spot, with a few satellite spots. The remaining regions are all small, weak and magnetically simple and either stable or gradually decaying.

A dimming event just west of the centre disc occurred around the time of the C2 flare and generated a large CME, which has been modelled to be Earth directed and forecast to arrive at Earth 11 or 12 Nov.

**Solar Wind / Geomagnetic Activity:** Solar winds at L1, as observed by ACE and DSCOVR, showed the waning enhancement from a high speed stream associated with CH67/-, falling from Strong to Elevated , around 700 to 550 km/s. Density was below average. The total interplanetary magnetic field strength (Bt) has been weak and consistently between 3-5nT. The north-south component (Bz) varied weakly, and was often negative, between -4 and +4 nT. Phi angle has been predominantly negative (towards the Sun), with just a few brief variations. Geomagnetic activity has been Quiet to Unsettled (Kp 1-3).

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux started at background levels, but then increased to moderate levels later in the 24 hour period in response to the C2 flare and associated CME. GOES16 high energy (greater than 2MeV) electron flux was at high levels between 09/21115 and 10/0930 UTC, peaking at 2730 pfu at 10/0015 UTC. The associated 24-hour fluence gradually increased through the period, ending at 1.15e8 integrated pfu at 10/1200 UTC. The fluence observation at 10/0000 UTC was 9.92e7 integrated pfu.

## Four-Day Space Weather Forecast Summary

**Solar Activity:** Generally Low solar activity is expected through the period, but with a chance of isolated M-class flares. Returning or new regions are likely to rotate onto the visible disc through the period, starting tomorrow, and so the chance of significant flares may increase over the coming days.

**Solar Wind / Geomagnetic Activity:** An Earth-directed CME is expected to arrive during second half of 11 Nov or early on 12 Nov. This may bring solar winds speeds of 550-700 km/s. Otherwise, the solar wind regime is expected to continue falling back to slightly elevated before the CME arrival, as the fast wind from CH67/- continues to wane. A further enhancement from CH68/+ is possible during second half of 12 Nov or on 13 Nov, to elevate solar wind speeds

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once again, though this is likely to be masked within the CME arrival.

Before the arrival of the CME Quiet to Unsettled (Kp 2-3) geomagnetic activity is expected, but with a chance of isolated Active (Kp 4) intervals today, due to residual high speed stream influence from CH67/-. Later on 11 or on 12 Nov the CME from 09 Nov should generate G1-G2/Minor to Moderate geomagnetic storms, with a chance of G3/Strong geomagnetic storms. Following the CME arrival geomagnetic activity is expected to gradually decline to Quiet to Unsettled (Kp 2-3) levels by the end of the period.

**Energetic Particles / Solar Radiation:** There is a slight chance that the high energy (greater than 10MeV) proton flux reaches S1 levels, due to the locations of the regions on the disc that are most likely to produce significant flares, and also because of the current slight enhancement in the high energy proton flux.

High energy electron flux (greater than 2MeV) is expected to remain predominantly at High levels until the arrival of the expected CME lter on 11 or on 12 Novw, then rapidly falling to background or moderate levels. As the expected geomagnetic enhancement subsides later in the forecast period so the high energy electron flux levels are expected to increase again, perhaps reaching High levels again during days 3 and 4 (12 and 13 Nov). The associated 24-hour electron fluence is expected to exceed the Active (1e8 integrated pfu) threshold today and tomorrow, dropping below after the CME arrives, and then possibly reaching Active levels again during day 4.

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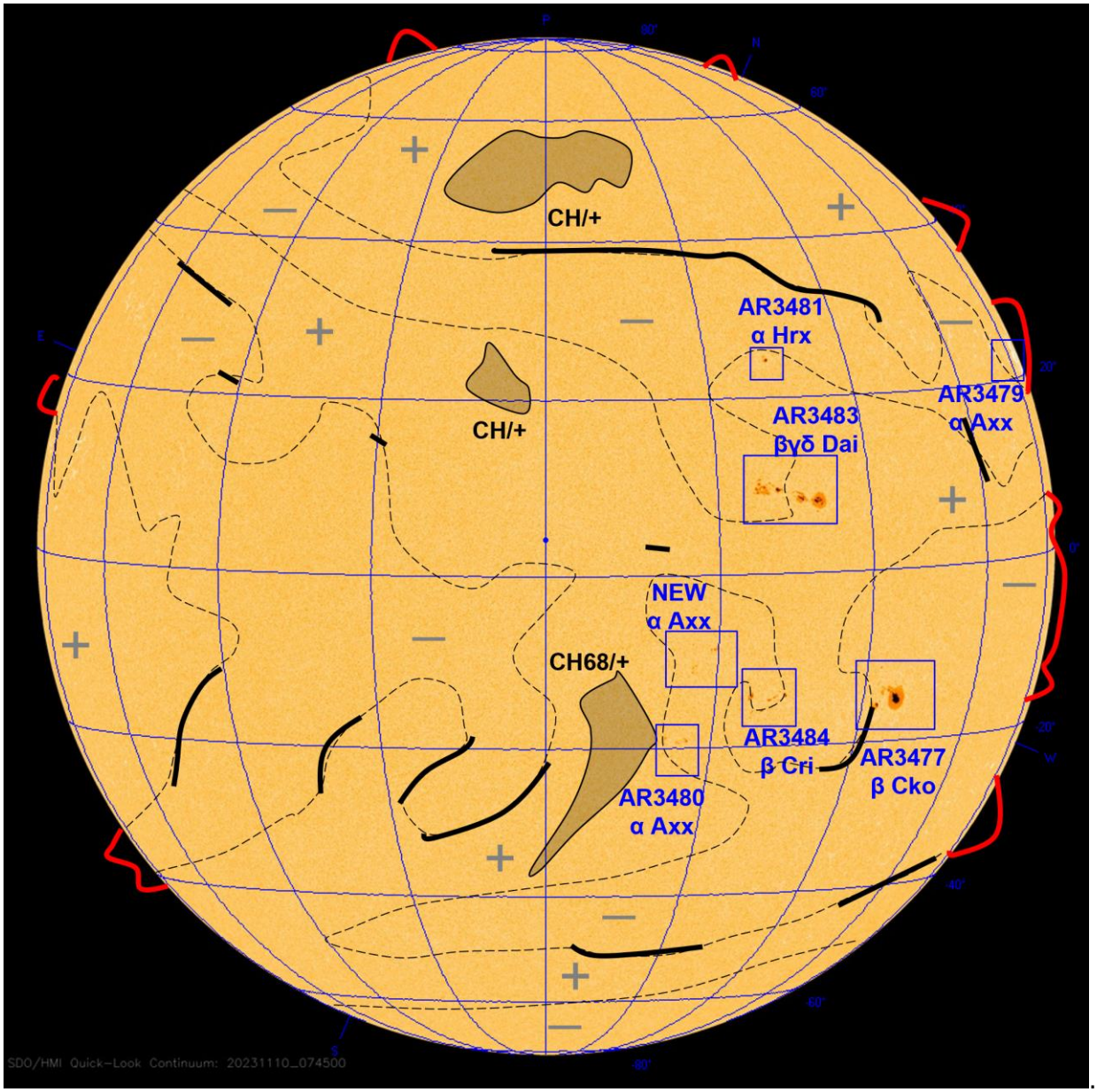
**Figure 1. Solar Analysis Valid 10/0800 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

Confidence is high that an Earth-directed CME will arrive during the forecast period, as a full halo CME was observed in imagery following a C2 flare and large coronal dimming event on the 9th. This CME is expected to bring solar winds speeds of 550-700 km/s. Uncertainty in arrival time is due to lack of any side-on observations which would help determine the cone angle/speed relationship to a greater degree. Current estimations are for a wider cone angle and slower CME speed allowing for a probable arrival time around 0000 UTC on 12 Nov. Other analyses show the possibility of arrival from as early at 1200 on 11 Nov and as late as 0000 UTC on 13 Nov. A G3 watch has been issued for this event starting 1200 UTC on 11 Nov, lasting for 24 hours.

Before the arrival of the CME Quiet to Unsettled (Kp 2-3) geomagnetic activity is expected, but with a chance of isolated Active (Kp 4) intervals today, due to residual high speed stream influence from CH67/-. Later on 11 or on 12 Nov the CME from 09 Nov should generate G1-G2/Minor to Moderate geomagnetic storms, with a chance of G3/Strong geomagnetic storms. Following the CME arrival geomagnetic activity is expected to gradually decline to Quiet to Unsettled (Kp 2-3) levels by the end of the period.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 20 | 70 | 90 | 30 |
| Strong | G3 | No | 1 | 30 | 30 | 1 |
| Severe | G4 | No | 1 | 5 | 5 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 09/1600 | Full Halo | Filament nr 3480 | Central | 700 km/s | 12/0000 UTC | Full halo, likley. Low confidence in arrival, could be earlier on 11 until 13 Nov. |

**Figure 2: MOSWOC ENLIL**

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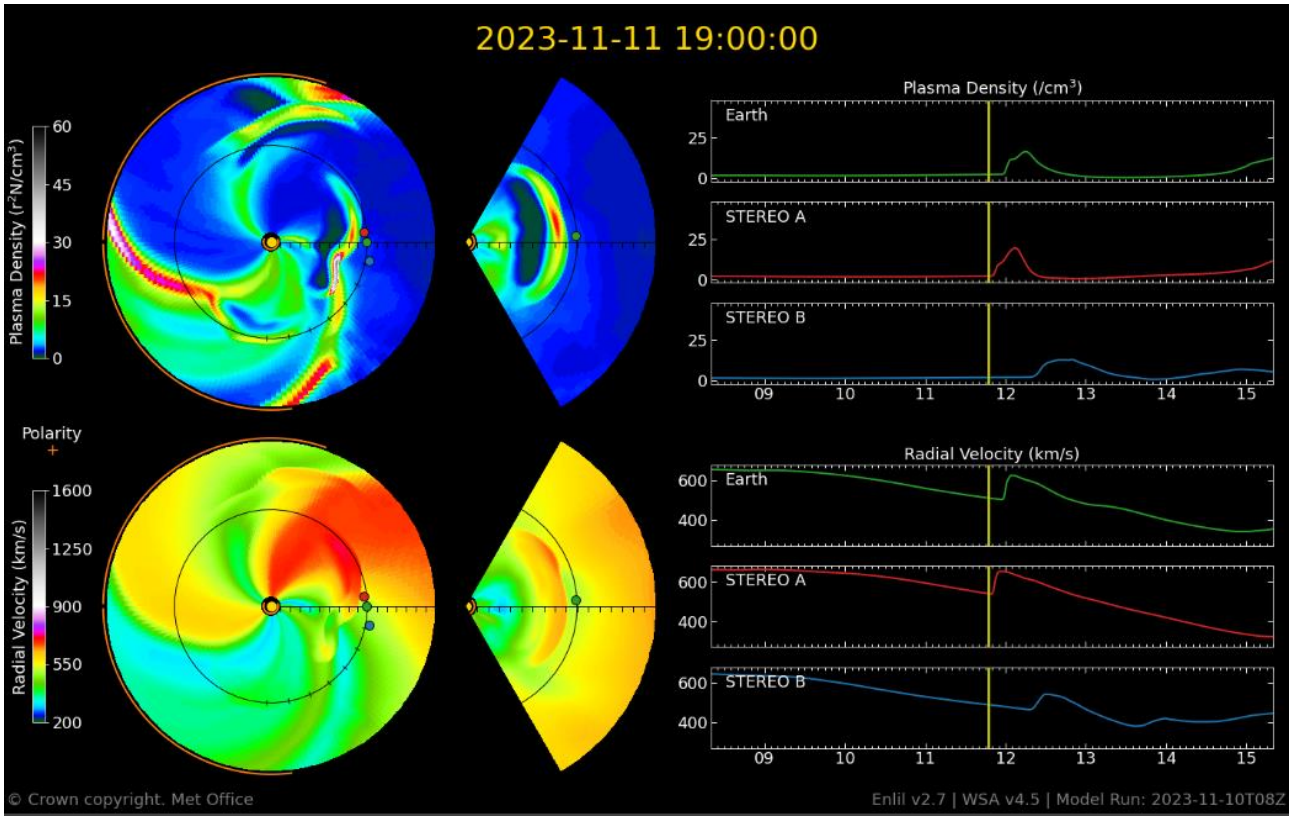


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# Met Office Space Weather Technical Forecast

## Radio Blackouts - X-Ray Flares:

There are currently seven regions on the visible disc. AR3483 is the most complex spot on the disk, now with a delta magnetic structure in it's trailing portion, and maturing penumbra within the intermediate spots. AR3477 (Cko/Beta-Gamma) in the southwest remains the largest group, comprising of one large, asymmetric and mature spot, with a few satellite spots. The remaining regions are all small, weak and magnetically simple and either stable or gradually decaying. Solar activity has been Low with isolated C-class flares observed. The source region of many of the flares in the past 24-hours has been AR3483 with a peak of C2 at 09/1118 UTC. Activity is expected to remain Low, with a Chance of isolated M-class flares. The flare risk has been reduced from raw probabilities, owing to the continued stability of AR3477. The most likely source of significant flares through the coming period remains AR3483.

| X Ray Flares<br>Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| Active | R1-R2 M Class | No | 20 | 20 | 20 | 20 |
| Very Active | R3 to R5 X Class | No | 1 | 1 | 1 | 1 |

## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at moderate levels, most likely in response to the long duration C2 flare which peaked at 09/1118 UTC and associated halo CME. The current enhancement is likely to continue through today, with a slight chance of a S1 event occurring should any further similar events happen. This chance continues for the rest of the period as the regions most likely to produce significant flares (AR3477, AR3480 and AR3483) continue across favourable geo-effective longitudes.

| Radiation Storms<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| Active | ≥ S1 | No | 10 | 10 | 10 | 5 |
| Very Active | ≥ S3 * | No | 1 | 1 | 1 | 1 |

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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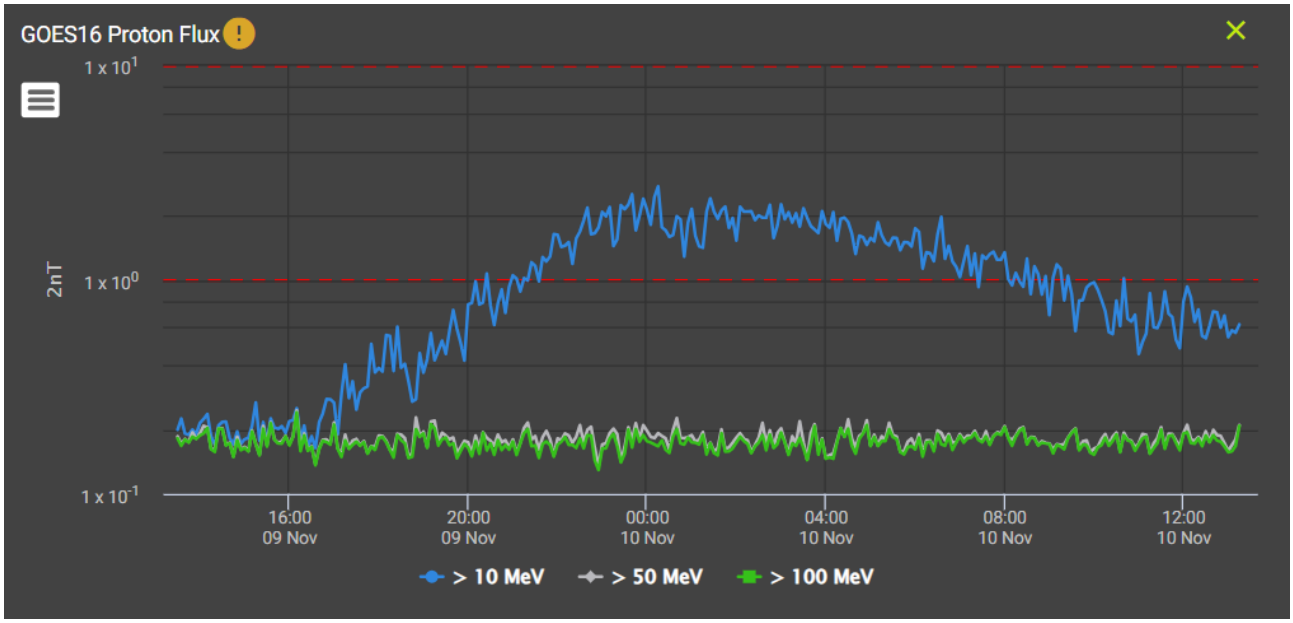
**Figure 3: 24 hour proton trace**

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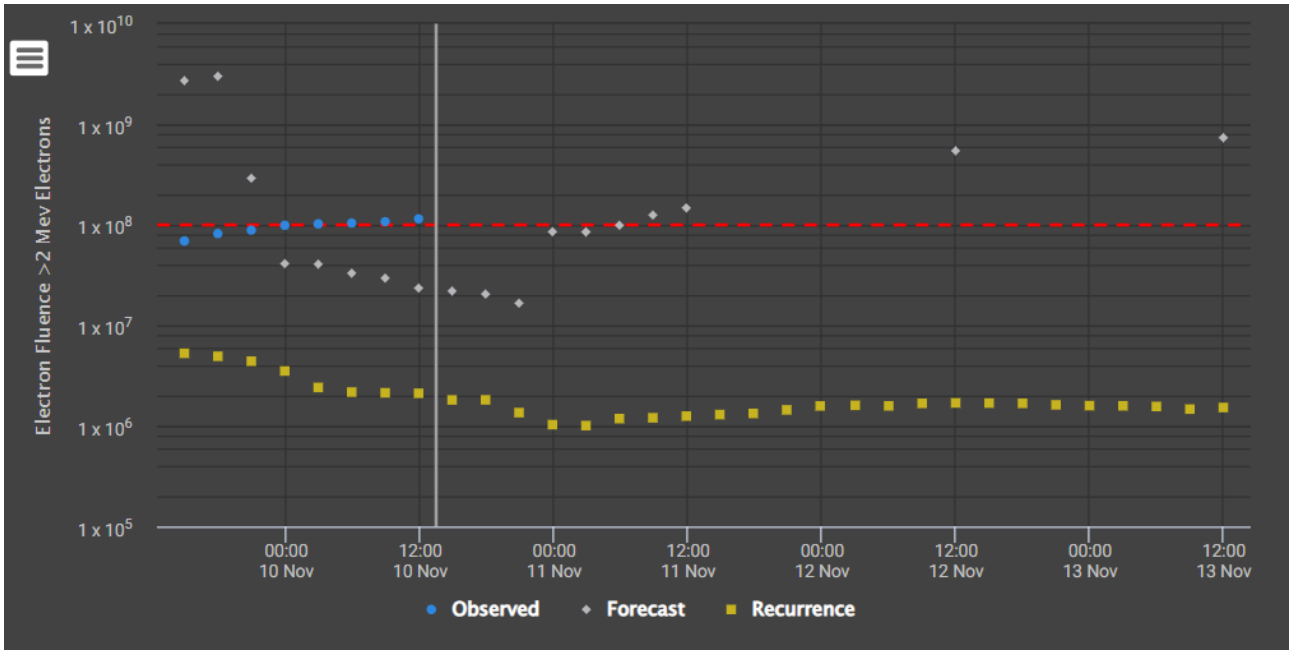
### High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is expected to remain predominantly at High levels until the arrival of the expected CME later on 11 or on 12 Nov, then rapidly falling to background or moderate levels. As the expected geomagnetic enhancement subsides later in the forecast period so the high energy electron flux levels are expected to increase again, reaching High levels again during days 3 and 4 (12th and 13th). The associated 24-hour electron fluence is expected to exceed the Active (1e8 integrated pfu) threshold today and tomorrow, dropping below after the CME arrives, and then possibly reaching Active levels again during day 4 as the high energy electron flux recovers.

The overall trend of the MOSWOC REFM model is currently underestimating the fluence, and is showing a decreasing trend through today, with a rising trend thereafter. This is considered to be offering poor guidance, with an increasing trend forecast through today and with Active threshold expected to be breached, followed by a decreasing trend later on 11 or more likely on 12 Nov following the arrival of the CME from 09 Nov.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 90 | 90 | 20 | 40 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

**Figure 4: MOSWOC REFM**

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